WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: IA1021

Title: Complementary Investigations for Implementation of Remote, Non-Contact Measurements of Streamflow in Riverine Environment

Focus Categories: Water Quantity, Non Point Pollution

Keywords: free-surface velocity index, streamgaging stations, in-situ measurements, non-contact measurements, discharge measurement

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Congressional District: 1st Congressional District of Iowa

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Abstract

Discharge estimation is essential for assessment of transport of pollutant and sediment in rivers. Rating curves used for discharge measurements at USGS streamgaging stations typically involve assumptions regarding the variation of velocity with depth. This is needed to convert point velocity measurements into depth-averaged velocity and river discharge for the cross-section. Velocity distribution assumptions usually stem from semi-empirical relationships derived for boundary-layer flows. Although assumed velocity distributions represent the velocity profile quite well for most of the flow depth, there is substantial experimental evidence showing that they may be inaccurate at or near the free surface, where intricate and sensitive mechanisms can alter the assumed velocity distribution.

Recently, the relationship between free-surface velocities and the velocity distribution in open-channel flows has emerged as a fundamental question for river discharge estimation. Specifically, the USGS Hydro 21 Committee has initiated a pioneering effort to remotely measure free-surface velocities for flow discharge estimation in rivers. Proof-of-concept, in-situ measurements have demonstrated the potential for remote sensing of both channel bathymetry and free-surface velocities using radar-based techniques. Free-surface velocity is estimated from the backscattering produced by short-wavelength waves traveling on the channel free surface. However, to utilize these or similar measurements for discharge estimation, there is an immediate need to understand (1) how internal/external factors generate short-wave "roughness" and alter

velocity profiles near the free surface, and (2) how free-surface velocities are related to depth-average velocity for a variety of flow conditions and channel configurations. Using laboratory and field measurements, the proposed research aims to elucidate the nature and characteristics of the short free-surface waves and establish relationships between free-surface velocity and depth-averaged velocity for a wide range of practical flow situations in artificial and natural waterways. This research is designed to complement the ongoing work of national importance conducted by the Hydro-21 Committee. Initial laboratory experiments will identify and quantify the effects of various secondary factors on the velocity distribution in the water column. Field measurements are planned in the second part of the study for evaluation of the flume experiments findings and for assessment of the impact of the secondary factors acting at natural scales. It is expected that this multi-prong approach will provide the needed operational guidance for nationwide implementation of this new generation of instruments for non-contact discharge measurement.

The laboratory equipment and facilities needed for this research will be provided by the Iowa Institute of Hydraulic Research (IIHR). This field testing involves a strong collaboration with USGS personnel and their ongoing research efforts in non-contact discharge measurement. Use of concurrent measurement techniques during USGS-coordinated field campaigns will assess the accuracy with which non-contact measurements in conjunction with the newly formulated velocity relationship are able to produce discharge estimates, and improvements over conventional measurement techniques.